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An assessment of NAFO roughhead grenadier Subarea 2 and 3 stock.

by

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ABSTRACT

The aim of this paper is to present the status of NAFO roughhead grenadier Subarea 2 and 3 stock based on different assessments models using all the available information. Different assessment methods have been applied based on the data available described above. The assessment was carried out with three different methods: Extended Survivors Analysis (XSA, Shepherd, 1999; Darby and Flatman, 1994), a Stock-Production Model Incorporating Covariates (ASPIC, Prager 1994 and 2004) and a qualitative assessment based on survey and fishery information.

XSA and ASPIC results are considered uncertainties due to the low Fishing mortality estimated compare with the natural mortality level assumed in the case of the XSA and due to the lack of contrast in the data used in the ASPIC case. Although all these problem both models results present a very similar trend in the fishing mortality and biomass values and are comparable to the qualitative assessment base on the Canadian fall survey series (Div. 2J+3K) and the Spanish survey in Divisions 3NO that there are considered by the NAFO Scientific Council as the best survey information to monitor trends in resource status.

Biomass presents in all methods a general increased trend in the analysed period with its maximum level in the last years. With regard to fishing mortality estimates from different methods, it can be observed that the trends of the different estimations of F were very similar and that the actual level of F is the minimum of the period due to the increase of the biomass and the decrease of the catches in the last years. The strong 2001 year class have been weaker than expected since 2005 in both survey indices. The level of the recruitment in last period appears to be smaller than the observer before.

INTRODUCTION

Roughhead grenadier (*Macrourus berglax* Lacépède, 1802) is an abundant widespread fish species in the North Atlantic, usually found both on the shelf and on the continental slope (Scott and Scott, 1988; Savvatimsky, 1994). It is predominant at depths ranging from 800 to 1,500 m (Murua and De Cárdenas, 2005), although they may inhabit depths between 200 and 2,000 m (Snelgrove and Haedrich, 1985; Murua and De Cárdenas, 2005). It has, however, been rarely found in depths down to 2,700 m (Wheeler, 1969). This species is commonly found in temperatures ranging from about -0.5 to 5.4 °C (Atkinson and Power, MS 1987).

Roughhead grenadier is becoming an important commercial fish in the waters managed by the Northwest Atlantic Fishery Organization (NAFO), especially in the NAFO Regulatory Area (NRA) and reliable information is needed for its assessment. The fishery for roughhead grenadier is unregulated as it is taken as by catch in the Greenland halibut (*Reinhardtius hippoglossoides*) fishery, mainly in NRA Divisions 3LMN. Most roughhead grenadier catches

are taken by trawl and the only management regulation applicable to roughhead grenadier in the NRA is a general groundfish regulation requiring the use of a minimum 130 mm mesh size.

The knowledge on the biology and population dynamics of Macrouridae is sparse (Gordon, 1979; Middleton & Musick, 1986; Atkinson, 1995; D'Onghia et al., 2000). In particular, little has been published on the biology, growth and reproduction of roughhead grenadier on both sides of the North Atlantic. Moreover, the age structure and growth of the roughhead grenadier, based on otolith readings of specimens captured in the North-West Atlantic, were estimated by Murua and González (2006).

The stock structure of this species in the North Atlantic remains unclear because there is little information on the number of different populations that may exist and their relationship. In the Northwest Atlantic Fisheries Organization (NAFO) area, roughhead grenadier is distributed throughout Subareas 0 to 3. However, for assessment purposes, NAFO Scientific Council considers the population of Subareas 2 and 3 as a single stock (NAFO, 2005). Although the knowledge available on the biology of this deepwater species is not extensive, there is more information than could be expected for such a species. And over the last few years, more biological information as well as research survey indices have been analysed (Murua et al., 2005). Therefore, the aim of this paper is to present the status of this stock based on different assessments models using all the available information.

Data

Catches

In 1998 Power and Maddock Parsons revised the roughhead grenadier catch statistics since 1987 for assessment purpose (Figure 1 and Table 1). Nevertheless, only the revised catches since 1992 are used in this paper because the length compositions, and thus, age compositions, were not available before 1992. Most of the catches were taken in Div. 3LMN by Spain, Portugal and Russia fleets. Catches of roughhead grenadier increased sharply from 1989 (333 tonnes) to 1992 (6725 t); since then until 1997 total catches have been about 4000 t. In 1998 and 1999 catches increased and were near the level of 7000 t. Since then, catches decreased to 3000–4000 tonnes in 2001–2004 and to 600–800 t in the period 2007 - 2009.

Length Distributions

Roughhead length frequencies from the Spanish, Portuguese and Russian trawl catches for 2009 in Div. 3LMNO are available from Gonzalez-Costas et al. (2010), Vargas et al. (2010) and Skryabin and Pochtar (2010) respectively. Table 2 presents the availability of the length distribution in the series. Due to the growth differences between sexes, length and age data have been analysed by sex. The Spanish and Portuguese lengths frequencies are presented as pre anal fin length (AFL), while the Russian ones as total lengths. The roughhead length compositions from the Russian catches have been converted to AFL using the total length / AFL relationship presented by Murua and Motos (1997). The total length distributions for these three countries are presented in Table 3.

Catch-at-Age

Ageing was based on otoliths from specimens caught in NAFO Divisions 3LMN. The total catch-at-age numbers presented by González-Costas and Murua (2007) have been updated with the 2007, 2008 and 2009 data (Table 4). Table 1 presents the data available to create the catch-at-age matrix. The associated mean weights and mean length by age are presented in Table 4. Most of catches are composed between ages 4 and 13, with a mode at age 8. In the last two years the mode was a slightly different, 7 years in 2008 and 6 years in 2009.

Research Survey Data

Biomass indices for the roughhead grenadier Subareas 2 and 3 stock are available from various research surveys, with different depth and area coverage (Table 5). None of them cover the total area and depth distribution of this stock.

Canadian fall survey: Stratified random bottom trawl surveys have been conducted in Div. 2GHJ and 3KL in fall since 1978, usually in October-November. Since 1990 the survey also covered Div. 3NO. Until 1995 an Engel trawl was used, changed since then to a Campelen 1800. Surveys depth is up to 1500m in Div. 2GHJ and 3K and to 730 m in Div. 3LNO, extended to 1463 m after 1995. A description of those surveys is in McCallum and Walsh (1996) and Power and Parsons (1998). Operational difficulties in some years lead to incomplete coverage (depth and surface) of

the survey (Brodie 2005; Healey and Dwyer, 2005, Healy 2009). The estimates from 1995 onwards are not directly comparable with the previous time series because of the change in the survey gear. Taking into account the incomplete coverage of some strata in divisions 2GH and 3LMNO from 1995-2009, only the indices of division 2J and 3K are comparable from 1995 onwards. The roughhead biomass index (2J3K MWPT) from this survey since 1995 are presented in Table 6. From 1995, the biomass of this survey in Divisions 2J and 3K shows a continuous increasing trend, reaching its maximum in 2009 as shows Figure 2. Figure 3 shows the length distributions for Division 2J and 3K since 1995.

Canadian spring survey: Stratified random bottom trawl surveys have been conducted in Div. 3L, 3N and 3O in spring since 1978. A description of those surveys is found in McCallum and Walsh (1996). Until 1996 an Engel trawl was used, changed to a Campelen 1800 since then. The depth range of the surveys is up to 731 metres. But again in this case a direct comparison of the biomass levels through the whole time series is not possible due to the change in the survey gear in 1995. Operational difficulties in 2006 resulted in incomplete coverage of the survey in Div. NO and the estimate for this year is not directly comparable with those earlier in the time series. Since 2007 this indices is not available for this species. Figure 4 and Table 6 present the biomass of this survey since 1996 till 2005. From 1996 to 2004, the biomass level does not present a clear trend. In 2005, the biomass index had a big increase. Biomass estimates from the spring survey series are considerably lower than the ones obtained in the autumn series, as the spring surveys cover only the southern divisions and the shallower depths, where according to other information this species is less abundant.

Canadian deepwater survey: Canada conducted deepwater bottom trawl surveys (750 – 1500 m.) in 1991, 1994 and in 1995 in Divisions 3 KLMN. The results of those surveys were reported by Atkinson et al. (1994) and Bowering et al. (1995), and are presented in Table 6. Most part of the biomass was taken in Div. 3L and 3M, which confirms that the stock in those Divisions is distributed beyond the depths covered by the spring surveys in those Divisions.

Flemish Cap (EU Spain and Portugal) 3M survey: EU- Spain and Portugal conduct a stratified bottom trawl survey in Div. 3M since 1988, up to depths of 730. The survey procedure is described in Saborido-Rey and Vázquez (2003). Since 1991, the survey was made with the R/V Cornide de Saavedra. In 2003 this vessel was replaced by the R/V Vizconde de Eza. The former series of Cornide de Saavedra was transformet to the new R/V Vizconde de Eza units following the method presented by Gonzalez Troncoso and Casas (2005). In 2004 the depth coverage of this survey has been extended to 1463 m. The roughhead grenadier biomass indices from this survey series (Vazquez 2010) until 730 m from 1991 to 2009 and until 1400 from 2004 to 2009 m are presented in Table 6 and Figure 5. The 730 m. biomass indices present a peak in 1993. From then until 2002, the biomass index was more or less stable at values in between 1 and 2 kg per tow. From 2002 onwards, the biomass index shows an increasing trend, reaching a historical maximum in 2006. Since 2007 the indices have been variable with a general decreased trend, reaching their historical minimum in 2009. The 1400 indices show a decreased trend since the beginning of the series. Figure 6 presents the age distributions of the EU Flemish Cap survey from 1994 to 2009 until 700 meters depth by sex, where it can be clearly appreciated a strong 2001 year class in 2003 and 2004 but since 2005 this 2001 year class have been weaker than expected.

Spanish 3NO Survey: Spain conduct a stratified random spring bottom trawl survey in the NAFO Regulatory Area Division 3NO since 1995. In 2001 the vessel and the trawl gear were replaced. The transformed entire series of mean catches, biomass and length distributions for Roughhead grenadier were presented by Gonzalez-Troncoso et al. (2010). The roughhead grenadier biomass index from this survey series is presented in Table 6 and Figure 7. From 1997 to 2002 the biomass indices of this survey did not show a clear trend. However, since then the biomass index has increased and in the period 2004-2006 reached the maximum level. In 2007 decreased to the 2003 level. In 2008 and 2009 the indices showed a slight increase. The age distributions of the survey series (Figure 8) showed a strong 2001 year class during 2003 and 2004 survey as it was observed in the EU Flemish Cap survey but since 2005 this year class have been weaker than expected. Last year survey a signal of this year class appears again with 8 years old.

Maturity Ogive

The maturity ogive used to calculate the Spawning Stock Biomass (SSB) was estimated from ovaries collected in the Flemish Cap research survey and commercial sampling in NRA Division 3LMNO during 1998-2000. The maturity

ogive was estimated microscopically, by means of histology (Murua, 2003), and this constant ogive was applied to the whole time series of the data (1992-2009).

ASSESSMENT METHODS

Different assessment methods have been applied based on the data available described above. The assessment was carried out with three different methods: Extended Survivors Analysis (XSA, Shepherd, 1999; Darby and Flatman, 1994), a Stock-Production Model Incorporating Covariates (ASPIC, Prager 1994 and 2004) and a qualitative assessment based on survey and fishery information.

Extended Survivors Analysis (XSA)

Extended Survivors Analysis was applied to the commercial catch-at-age data for roughhead grenadier in NAFO Subarea 2 and 3 from 1992-2009 to assess the current status of the stock. The XSA model formulation was based on the analysis made by Gonzalez-Costas and Murua (2007) and Gonzalez-Costas (2009) with the following configuration:

- Catch data for 18 years (1992-2009). From 1992 to 2008. Ages 3 to 17.
- Tuning series: EU Flemish Cap survey series (700 m) between 1994 and 2009 and restricted to ages 3 to 16 and the Spanish 3NO research survey series between 1997 and 2009 and ages 3 to 16.
- Tapered time weighting not applied.
- Catchability independent of stock size for all ages.
- Catchability independent of age for ages ≥ 15
- Survivor estimates shrunk towards the mean F of the final 2 years or the 2 oldest ages.
- S.E. of the mean to which the estimates are shrunk = 1.000
- estimates derived from each fleet = 0.300
- Prior weighting not applied.
- Plus group was established 17+ and F_{bar} was defined as the mean F for ages between 6 and 13 years.

With regard to the tuning indices used in the XSA assessment, only the European Union (EU) Flemish Cap research survey in NAFO Division 3M till 700 m. depth and the Spanish research survey in Divisions 3NO were used. Catch-at-age in numbers is given for both surveys as mean numbers per tow (MNPT) and present in Table 7. Natural mortality (M) at age was assumed to be constant and was set at 0.1 for all years. The reason for selecting this value for M is that the roughhead grenadier is a long-lived species that inhabits a stable deep-sea ecosystem. This value has been applied in the assessment of some stocks of roundnose grenadier with similar biology and inhabiting similar ecosystems (ICES, 2006).

Stock-Production Model Incorporating Covariates (ASPIC)

A non-equilibrium surplus production model incorporating covariates (ASPIC) was applied to nominal catch for roughhead grenadier in NAFO Subarea 2 and 3 from 1992-2009 and survey biomass indices. The logistic (Schaefer 1954 and 1957) production model used assumes logistic population growth. Initial biomass (expressed as the ratio: $B1/K$), K , MSY , and catchability coefficients for each biomass index (q_i) were estimated using non-linear least squares of survey residuals. The survey indices and catch series used in the production model were the following:

- Nominal catches 1992-2009
- Flemish Cap survey indices (Mean Weight per Tow) till 700 m. from 1992 to 2009.
- Spanish 3NO survey indices (Mean Weight per Tow) from 1997 to 2009.
- Canadian Autumn survey 2J3K indices (Mean Weight per Tow) from 1995 to 2009.

Several runs were carried out in ASPIC version 5.33 to investigate the sensitivity of the ASPIC model to various input specifications and values (starting estimates for $B1/K$, K , MSY and the random number seed). The inputs for these run are presented in Table 8. The survey data was treated in all model formulation as follow: the Flemish Cap survey indices as CPUE type (CC) because this is the longer series and the most important catches come from Flemish Pass and the other two as Index of biomass type (I). Spanish 3NO survey as annual average index (I1) because it is carried out in May –June and the Canadian Autumn survey as end of the year index (I2) because normally it is carried out between October and December. Due to fit problems different runs were made with different fixed values $B1/K$ (Table 8).

Qualitative assessment based on survey and fishery information.

This assessment is qualitative and is based on the survey trend and fishery information to try to estimate a trend in mortality based on proxies as catch/survey biomass ratios and catch curves. With this method we can have an idea of the level and trend of the fishing mortality of the stock.

RESULTS AND DISCUSSION

Extended Survivors Analysis (XSA): Model converged after 89 iterations and the model fit is considered to be acceptable. Catchability is the link between survey catches and population abundance as estimated from the catch-at-age data and the model assumes that surveys catchabilities-at-age are constant with respect to time. The Standard Error (SE) of the log catchability for the EU Flemish Cap and Spanish 3NO surveys by age are presented in Figure 9. Values higher than 0.5 can be interpreted as fit problems. The major problems occurred at younger ages for both surveys however, these ages are less frequent in the catches. The EU Flemish Cap survey log catchability SE were greater than the Spanish 3NO survey and this could be related to the differences in depth coverage in the two surveys. The log catchability residuals for each survey by year (Figure 10) show that there were no strong trends in the residual time series in the Spanish 3NO survey. The EU Flemish Cap survey log catchability residuals were greater than the Spanish 3NO survey and the large residuals occurred at younger ages. In 2009 for this survey the residuals for all ages are negatives and show a clear year effect. This effect can be followed in other species and could be related with problems in the survey in this particular year.

Total biomass, mean F between ages 6 to 13 (F_{bar}) and recruitment (Age 3) results are plotted in Figure 11 and presented in Table 9. Model results indicated that the stock biomass has an increase trend in the all period analyzed and that the current level of total biomass was twofold in comparison to the beginning of the time series. The biomass estimated for the beginning of 2009 was around 70,000 tonnes, which is at the same level as the highest value on 73,000 tonnes in the time series observed in 2007. Fishing mortality has declined since 1998 and it showed the second lowest value of the time series (0.021) in 2009. The current level of F is much smaller than the value of the assumed natural mortality. The current level of the recruitment is less than the level observed in the nineties. The retrospective results (Figure 12) indicate that there was a clear retrospective pattern in the model estimates in the last years, e.g., fishing mortality was underestimated whereas total biomass was overestimated. In last year's assessment, the recruitment estimates for 2003 and 2004 were much lower than was estimated in previous years. The results are considered to be uncertain due to a number of factors that might influence the quality of the outcome, such as the short time series of data, the wide age range of the population and the low Fishing mortality estimated compare with the natural mortality level assumed.

Stock-Production Model Incorporating Covariates (ASPIC): Table 8 shows the main characteristics and the results of the different runs made with ASPIC. All of the tried runs show a poor fit as we can observe in the contrast and nearness indices. In a good fit these values should be very close to 1. In all run with our data, principally the contrast index value was very low indicating a low contrast in the data to calculate all the parameters. Other signal of the poor fit was the low R^2 value for all the indices showing that the majority of variance in survey indices was not explained by the model.

When we tried to calculate all parameters, in the first four run show in Table 8, we found many estimation difficulties in all these runs. Normally the model estimated very high values for the K parameter close to the limit boundary set in the inputs and very low values for the $B1/k$ parameter. These high calculated values for K have a very difficult biological explanation. To avoid this problem it was fixed the $B1/K$ value in the inputs and it was tried to fit the model, even with the fixed parameters the model was unable to find a stable solution probably due to the lack on contrast in the survey series used. All the series have a general increase trend in all the period analysed. Even all the fit problems and uncertainties the majority of the run show a similar trend in the biomass and mortality (Figure 13).

Qualitative assessment based on survey and fishery information: Canadian Divisions 2J and 3K fall index and the Spanish research survey in Divisions 3NO have been considered in the last assessment as the best information in order to monitor trends in resource status (NAFO 2009) because they cover depths down to 1,500 metres and, hence, cover the depth distribution of roughhead grenadier fairly well (Murua and De Cardenas, 2005). The roughhead grenadier biomass indices of the fall Canadian survey (2J+3K) and the Spanish 3NO survey show a general increasing trend from 1995 onwards. However, the biomass trend of the EU Flemish Cap survey (< 720 m and till

1400 m) presented a decrease trend in the last years. The catch / biomass (C/B) indexes obtained using the Canadian fall survey and the Spanish 3NO biomass index in the period 1995-2009 (Fig. 14) show a clear decrease trend from 1995 to 2009, due to the increase in the survey biomass and the low level of catches in the last years. Figure 15 presents the abundance series (MNPT) for ages 3 of the EU Flemish Cap survey and the Spanish Div. 3NO survey from 1994 to 2006. A strong 2001 year class can be clearly seen in 2004 in both series. Since 2004 the level of the recruitment is below the mean in both series. The strong 2001 year class have been weaker than expected since 2005 in both survey indices.

The Z estimate from the catch curve based upon commercial catch at age data (1992-2009) was 0.356 for ages 8 to 20 ($R^2=0.99$) and 0.169 for ages 6 to 13 ($R^2=0.68$). The value estimate from the catch curve of the UE Flemish Cap survey (1994-2009) was 0.456 and 0.412 for the catch curve of the Spanish 3NO survey data (1997-2009) for ages 8 to 20 and 0.202 and 0.242 for ages 6 to 13 (Fig. 16). The differences between the Z values estimated based upon catches, Spanish 3NO survey and the Flemish Cap survey can be explained due to different depth coverage of sampling. The value based on the Flemish Cap survey is likely to be an overestimation since this survey covers only the shallowest distribution of the resource. The level of Z is similar to the level calculated with the same method in the last assessments.

SUMMARY

XSA and ASPIC results are considered uncertainties due to the low Fishing mortality estimated compare with the natural mortality level assumed in the case of the XSA and due to the lack of contrast in the data used in the ASPIC case. Although all these problem both models results present a very similar trend in the fishing mortality and biomass values and comparable to the qualitative assessment base on the Canadian fall survey series (Div. 2J+3K) and the Spanish survey in Divisions 3NO that there are considered by the NAFO Scientific Council as the best survey information to monitor trends in resource status.

Biomass presents in all methods a general increased trend in the analysed period with its maximum level in the last years. With regard to fishing mortality estimates from different methods, it can be observed that the trends of the different estimations of F were very similar and that the actual level of F is the minimum of the period due to the increase of the biomass and the decrease of the catches in the last years. The strong 2001 year class have been weaker than expected since 2005 in both survey indices. The level of the recruitment in last period appears to be smaller than the observer before.

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Table 1.- STACFIS roughhead grenadier NAFO Subarea 2 and 3 nominal catches (t) by Division.

| Year | STACFIS RHG Nominal catches (t) by Division | | | | | | | | | TOTAL |
|-------------------|---|----|----|-----|------|------|------|-----|-------|-------|
| | 2G | 2H | 2J | 3K | 3L | 3M | 3N | 3O | Other | |
| 1987 | | | | | 912 | 7 | 82 | | | 1001 |
| 1988 | | 1 | | | 907 | | 52 | | | 960 |
| 1989 | | 2 | | 3 | 289 | 28 | 11 | | | 333 |
| 1990 | | 1 | 32 | | 2211 | 688 | 312 | | | 3244 |
| 1991 ^a | | | 12 | 113 | 2543 | 497 | 1093 | 10 | | 4268 |
| 1992 | | | 23 | 274 | 2582 | 2961 | 760 | 125 | | 6725 |
| 1993 | | | 10 | 193 | 996 | 1428 | 1680 | 61 | 27 | 4395 |
| 1994 | 1 | | 2 | 35 | 585 | 2301 | 1062 | 28 | 9 | 4023 |
| 1995 | 22 | 6 | 16 | 16 | 1199 | 1625 | 1074 | 20 | 4 | 3982 |
| 1996 | | | | | 1945 | 888 | 1300 | 2 | | 4135 |
| 1997 | 36 | 5 | 63 | 100 | 1774 | 922 | 1797 | 43 | | 4740 |
| 1998 | | | | | 2766 | 2190 | 2230 | 84 | 92 | 7362 |
| 1999 | | | | 61 | 2037 | 3127 | 1705 | 180 | 49 | 7159 |
| 2000 | | | | 139 | 1382 | 2109 | 888 | 38 | 211 | 4767 |
| 2001 | | | | 97 | 1465 | 753 | 754 | 48 | | 3117 |
| 2002 | | | | 147 | 1905 | 869 | 700 | 36 | | 3657 |
| 2003 ^b | 1 | 4 | 16 | 91 | 1342 | 886 | 1201 | 443 | | 3984 |
| 2004 | 4 | 8 | 19 | 58 | 1310 | 844 | 897 | 42 | | 3182 |
| 2005 | | 1 | 15 | 93 | 642 | 457 | 235 | 13 | | 1456 |
| 2006 | | | 21 | 54 | 696 | 488 | 111 | 6 | 44 | 1420 |
| 2007 | | | 10 | 22 | 294 | 191 | 146 | 1 | | 664 |
| 2008 | 0 | 0 | 1 | 3 | 347 | 355 | 132 | 9 | | 847 |
| 2009 | | | | 6 | 379 | 136 | 102 | 6 | | 629 |

^a Catch could not be well estimated; based on revised data is estimated to be 8000 to 14000 t. mixed roundnose and roughhead grenadiers. (Power and Parson 1988).

^b In 2003, STACFIS could not precisely estimate the catch.

Table 2 .- Roughhead grenadier Subarea 2 and 3 catches length distributions and ALK available by country and year.

| Data Country | Spain | Length Portugal | Russia | ALK Spain |
|-----------------|-------|--------------------|--------|--------------|
| 1992 | X | X | | |
| 1993 | X | | | |
| 1994 | X | | | |
| 1995 | X | X | | |
| 1996 | X | X | | |
| 1997 | X | X | X | |
| 1998 | X | X | X | |
| 1999 | X | X | X | X |
| 2000 | X | X | X | X |
| 2001 | X | X | X | |
| 2002 | X | X | X | X |
| 2003 | X | X | X | X |
| 2004 | X | X | X | X |
| 2005 | X | X | X | X |
| 2006 | X | X | X | X |
| 2007 | X | X | X | X |
| 2008 | X | X | X | X |
| 2009 | X | X | X | X |

In black only commercial information; In red commercial and Flemish Cap survey information

Table 3.- Roughhead grenadier Subarea 2 and 3 Spain+Portugal+Russia catches length distributions ('000) by year. Measure as pre anal fin length (AFL).

| Length (cm) | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|------------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 42 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 30 | 0 | 0 | 0 | 1 | 2 | 0 | 0 | 0 | 0 | 0 |
| 5 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 15 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 |
| 6 | 12 | 7 | 5 | 0 | 0 | 0 | 0 | 8 | 0 | 1 | 1 | 4 | 3 | 0 | 0 | 0 | 0 | 0 |
| 7 | 12 | 12 | 16 | 4 | 0 | 10 | 7 | 12 | 4 | 3 | 5 | 22 | 24 | 1 | 2 | 0 | 1 | 2 |
| 8 | 11 | 29 | 33 | 8 | 3 | 63 | 21 | 45 | 32 | 16 | 16 | 44 | 39 | 3 | 8 | 4 | 3 | 11 |
| 9 | 39 | 115 | 67 | 43 | 17 | 121 | 57 | 126 | 112 | 59 | 59 | 102 | 70 | 6 | 19 | 10 | 10 | 38 |
| 10 | 69 | 51 | 159 | 308 | 212 | 287 | 221 | 157 | 224 | 150 | 162 | 233 | 168 | 12 | 56 | 21 | 22 | 77 |
| 11 | 101 | 65 | 132 | 231 | 328 | 518 | 448 | 278 | 327 | 210 | 238 | 333 | 256 | 20 | 99 | 32 | 56 | 163 |
| 12 | 146 | 100 | 150 | 306 | 647 | 529 | 687 | 517 | 474 | 343 | 378 | 444 | 350 | 41 | 157 | 48 | 137 | 222 |
| 13 | 223 | 255 | 212 | 314 | 771 | 515 | 835 | 651 | 714 | 519 | 492 | 456 | 399 | 93 | 147 | 51 | 138 | 152 |
| 14 | 531 | 288 | 370 | 412 | 796 | 654 | 1290 | 591 | 810 | 853 | 727 | 761 | 497 | 133 | 156 | 49 | 169 | 111 |
| 15 | 742 | 368 | 418 | 529 | 705 | 811 | 2241 | 698 | 863 | 912 | 950 | 951 | 552 | 167 | 187 | 58 | 201 | 109 |
| 16 | 755 | 623 | 517 | 515 | 569 | 943 | 2287 | 719 | 1038 | 719 | 967 | 1134 | 621 | 214 | 233 | 49 | 212 | 88 |
| 17 | 710 | 850 | 774 | 612 | 615 | 752 | 1777 | 807 | 1185 | 657 | 782 | 1005 | 632 | 277 | 234 | 47 | 216 | 58 |
| 18 | 678 | 802 | 813 | 681 | 653 | 642 | 1093 | 660 | 891 | 589 | 600 | 769 | 541 | 268 | 276 | 46 | 128 | 66 |
| 19 | 720 | 560 | 690 | 671 | 504 | 572 | 902 | 725 | 680 | 456 | 389 | 557 | 371 | 219 | 197 | 46 | 91 | 45 |
| 20 | 571 | 421 | 471 | 418 | 503 | 528 | 561 | 709 | 417 | 279 | 253 | 356 | 263 | 172 | 114 | 40 | 72 | 26 |
| 21 | 551 | 245 | 299 | 282 | 511 | 333 | 402 | 580 | 241 | 155 | 158 | 244 | 191 | 121 | 60 | 43 | 29 | 15 |
| 22 | 494 | 203 | 211 | 185 | 189 | 228 | 281 | 358 | 171 | 95 | 117 | 154 | 154 | 82 | 51 | 34 | 29 | 16 |
| 23 | 350 | 219 | 174 | 97 | 155 | 210 | 216 | 380 | 139 | 66 | 75 | 117 | 90 | 59 | 37 | 31 | 17 | 11 |
| 24 | 395 | 231 | 149 | 91 | 63 | 154 | 213 | 276 | 84 | 53 | 61 | 94 | 93 | 55 | 30 | 27 | 17 | 12 |
| 25 | 198 | 204 | 150 | 60 | 60 | 128 | 115 | 258 | 99 | 46 | 57 | 71 | 66 | 36 | 31 | 26 | 8 | 15 |
| 26 | 176 | 188 | 113 | 66 | 62 | 79 | 96 | 167 | 96 | 41 | 50 | 49 | 43 | 22 | 18 | 23 | 11 | 15 |
| 27 | 121 | 109 | 88 | 73 | 14 | 47 | 49 | 166 | 65 | 32 | 40 | 45 | 41 | 23 | 16 | 20 | 19 | 10 |
| 28 | 131 | 74 | 64 | 59 | 50 | 45 | 74 | 125 | 44 | 29 | 43 | 36 | 29 | 14 | 21 | 18 | 6 | 9 |
| 29 | 117 | 75 | 47 | 48 | 60 | 54 | 29 | 87 | 37 | 24 | 42 | 26 | 27 | 12 | 12 | 15 | 2 | 6 |
| 30 | 64 | 52 | 49 | 17 | 85 | 41 | 30 | 69 | 14 | 19 | 31 | 39 | 22 | 8 | 9 | 10 | 1 | 5 |
| 31 | 46 | 50 | 28 | 31 | 17 | 35 | 38 | 70 | 21 | 18 | 25 | 21 | 20 | 7 | 6 | 8 | 1 | 4 |
| 32 | 38 | 55 | 28 | 25 | 0 | 23 | 57 | 60 | 18 | 8 | 21 | 13 | 17 | 9 | 7 | 4 | 5 | 5 |
| 33 | 22 | 11 | 15 | 15 | 0 | 27 | 12 | 73 | 9 | 9 | 16 | 7 | 7 | 8 | 4 | 3 | 1 | 2 |
| 34 | 17 | 13 | 15 | 9 | 10 | 18 | 14 | 35 | 10 | 9 | 12 | 8 | 7 | 4 | 7 | 3 | 0 | 2 |
| 35 | 8 | 9 | 9 | 1 | 0 | 6 | 13 | 21 | 9 | 7 | 10 | 9 | 5 | 5 | 5 | 2 | 1 | 3 |
| 36 | 8 | 4 | 3 | 0 | 0 | 5 | 11 | 21 | 18 | 3 | 8 | 6 | 2 | 4 | 1 | 1 | 1 | 0 |
| 37 | 1 | 1 | 4 | 4 | 0 | 0 | 7 | 9 | 15 | 2 | 2 | 2 | 2 | 5 | 1 | 1 | 0 | 1 |
| 38 | 0 | 0 | 3 | 0 | 0 | 1 | 2 | 9 | 0 | 1 | 1 | 1 | 1 | 2 | 0 | 1 | 0 | 0 |
| 39 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 2 | 0 | 2 | 1 | 0 | 0 | 2 | 0 | 0 | 1 | 0 |
| 40 | 14 | 0 | 2 | 0 | 0 | 2 | 0 | 0 | 12 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| TOTAL | 8080 | 6291 | 6281 | 6114 | 7598 | 8385 | 14085 | 9584 | 8875 | 6386 | 6789 | 8114 | 5609 | 2104 | 2208 | 770 | 1606 | 1301 |
| (Sp+Pt+Rus) Catch (t) | 6125 | 2054 | 1720 | 3923 | 3874 | 4500 | 7231 | 7053 | 4555 | 2954 | 3254 | 3869 | 2934 | 1157 | 1182 | 530 | 685 | 575 |
| Samples | 219 | 48 | 288 | 234 | 229 | 225 | 34 | 164 | 214 | 299 | 276 | 150 | 188 | 106 | 152 | 97 | 61 | 133 |
| Total catch (t) | 6725 | 4395 | 4023 | 3982 | 4135 | 4740 | 7270 | 7160 | 4767 | 3117 | 3657 | 4179 | 3290 | 1456 | 1420 | 664 | 847 | 629 |

Table 4.- Roughhead grenadier Subarea 2 and 3 total catches age distributions ('000), mean weights by age in gr. and mean length at age in cm.

**Abundance
('000)**

| Age | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|-------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 1 | 4 | 0 | 1 | 0 | 0 | 0 | 0 | 106 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 33 | 38 | 40 | 14 | 5 | 42 | 22 | 129 | 32 | 16 | 6 | 37 | 4 | 0 | 1 | 0 | 0 | 1 |
| 3 | 62 | 125 | 131 | 143 | 95 | 242 | 145 | 156 | 190 | 107 | 100 | 173 | 121 | 4 | 4 | 1 | 3 | 13 |
| 4 | 104 | 84 | 178 | 319 | 315 | 468 | 392 | 224 | 302 | 217 | 257 | 464 | 267 | 15 | 17 | 14 | 27 | 80 |
| 5 | 198 | 151 | 206 | 370 | 709 | 653 | 791 | 641 | 528 | 422 | 483 | 372 | 564 | 41 | 122 | 65 | 103 | 109 |
| 6 | 509 | 367 | 395 | 565 | 1162 | 926 | 1620 | 950 | 1118 | 916 | 1046 | 563 | 595 | 105 | 212 | 88 | 267 | 429 |
| 7 | 793 | 496 | 528 | 620 | 924 | 992 | 2213 | 962 | 983 | 1050 | 974 | 1190 | 736 | 222 | 323 | 106 | 371 | 238 |
| 8 | 1122 | 948 | 901 | 879 | 999 | 1271 | 3015 | 1238 | 1342 | 1170 | 1266 | 1709 | 1002 | 329 | 325 | 83 | 266 | 240 |
| 9 | 1080 | 1088 | 1062 | 912 | 922 | 1071 | 2226 | 1040 | 1693 | 913 | 874 | 1355 | 712 | 410 | 358 | 56 | 207 | 90 |
| 10 | 841 | 761 | 799 | 686 | 699 | 717 | 1216 | 808 | 1045 | 565 | 454 | 773 | 499 | 387 | 251 | 82 | 149 | 46 |
| 11 | 798 | 536 | 587 | 519 | 609 | 583 | 801 | 919 | 473 | 357 | 443 | 396 | 273 | 191 | 191 | 83 | 83 | 50 |
| 12 | 752 | 456 | 458 | 377 | 457 | 477 | 586 | 542 | 414 | 243 | 318 | 300 | 289 | 143 | 76 | 56 | 44 | 30 |
| 13 | 582 | 373 | 322 | 231 | 279 | 327 | 376 | 623 | 234 | 138 | 168 | 141 | 171 | 104 | 56 | 40 | 36 | 30 |
| 14 | 478 | 305 | 245 | 170 | 145 | 233 | 264 | 471 | 186 | 89 | 91 | 63 | 88 | 67 | 49 | 33 | 17 | 22 |
| 15 | 259 | 197 | 148 | 98 | 84 | 119 | 132 | 228 | 121 | 54 | 59 | 54 | 46 | 22 | 23 | 18 | 12 | 10 |
| 16 | 162 | 121 | 90 | 76 | 60 | 81 | 83 | 106 | 63 | 37 | 60 | 71 | 41 | 10 | 9 | 15 | 8 | 8 |
| 17 | 100 | 74 | 55 | 45 | 48 | 62 | 47 | 69 | 28 | 25 | 69 | 33 | 21 | 14 | 17 | 9 | 6 | 7 |
| 18 | 76 | 65 | 46 | 35 | 42 | 44 | 48 | 97 | 22 | 22 | 51 | 12 | 18 | 12 | 8 | 9 | 4 | 3 |
| 19 | 54 | 52 | 37 | 24 | 30 | 33 | 42 | 79 | 31 | 17 | 28 | 16 | 8 | 11 | 3 | 5 | 1 | 6 |
| 20 | 30 | 28 | 23 | 15 | 9 | 21 | 29 | 81 | 19 | 12 | 16 | 7 | 5 | 7 | 2 | 5 | 2 | 3 |
| 21 | 18 | 17 | 13 | 9 | 2 | 14 | 19 | 56 | 18 | 7 | 12 | 0 | 3 | 3 | 2 | 2 | 0 | 3 |
| 22 | 8 | 4 | 7 | 3 | 1 | 5 | 8 | 28 | 13 | 5 | 5 | 2 | 0 | 3 | 0 | 0 | 0 | 0 |
| 23 | 9 | 4 | 5 | 2 | 2 | 4 | 7 | 23 | 10 | 4 | 5 | 0 | 0 | 2 | 0 | 1 | 0 | 2 |
| 24 | 8 | 1 | 4 | 1 | 0 | 2 | 3 | 8 | 10 | 3 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 1 |
| Total ages | 8080 | 6291 | 6281 | 6112 | 7598 | 8385 | 14085 | 9584 | 8875 | 6388 | 6790 | 7736 | 5467 | 2104 | 2047 | 770 | 1606 | 1423 |

**Mean Weight
(gr)**

| Age | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|
| 1 | 11 | | 16 | | | | 30 | 10 | 14 | 13 | 22 | 34 | 4 | 4 | | | | |
| 2 | 40 | 51 | 49 | 80 | 165 | 107 | 107 | 127 | 116 | 99 | 61 | 91 | 41 | 62 | 16 | 68 | | 90 |
| 3 | 86 | 77 | 85 | 113 | 156 | 147 | 143 | 180 | 158 | 137 | 154 | 148 | 102 | 80 | 109 | 102 | 56 | 118 |
| 4 | 119 | 111 | 115 | 143 | 184 | 211 | 177 | 244 | 194 | 176 | 218 | 213 | 192 | 114 | 161 | 167 | 97 | 164 |
| 5 | 186 | 184 | 173 | 230 | 216 | 262 | 229 | 317 | 243 | 227 | 268 | 278 | 269 | 195 | 212 | 245 | 162 | 212 |
| 6 | 258 | 236 | 236 | 325 | 260 | 300 | 281 | 365 | 276 | 271 | 306 | 299 | 317 | 262 | 265 | 342 | 227 | 262 |
| 7 | 337 | 320 | 313 | 434 | 348 | 355 | 342 | 434 | 327 | 324 | 353 | 333 | 375 | 343 | 343 | 397 | 302 | 321 |
| 8 | 440 | 414 | 412 | 524 | 451 | 421 | 403 | 487 | 393 | 397 | 414 | 423 | 473 | 437 | 434 | 503 | 426 | 444 |
| 9 | 594 | 500 | 509 | 612 | 560 | 516 | 490 | 591 | 498 | 499 | 498 | 483 | 568 | 538 | 561 | 602 | 486 | 556 |
| 10 | 748 | 585 | 590 | 677 | 653 | 618 | 600 | 677 | 568 | 587 | 607 | 616 | 726 | 669 | 609 | 807 | 566 | 648 |
| 11 | 922 | 736 | 716 | 776 | 767 | 743 | 749 | 785 | 725 | 709 | 692 | 854 | 836 | 810 | 788 | 1116 | 686 | 817 |
| 12 | 1063 | 886 | 836 | 885 | 851 | 855 | 876 | 949 | 828 | 824 | 840 | 979 | 1072 | 988 | 1023 | 1203 | 853 | 1067 |
| 13 | 1226 | 1101 | 1039 | 1106 | 984 | 1033 | 1052 | 1151 | 1068 | 1033 | 989 | 1155 | 1361 | 1131 | 1282 | 1589 | 1325 | 1287 |
| 14 | 1446 | 1324 | 1280 | 1443 | 1245 | 1252 | 1299 | 1305 | 1353 | 1343 | 1412 | 1521 | 1546 | 1198 | 1709 | 1829 | 1268 | 1544 |
| 15 | 1683 | 1546 | 1530 | 1705 | 1696 | 1534 | 1544 | 1657 | 1561 | 1652 | 1565 | 1903 | 2234 | 1783 | 2160 | 2119 | 1590 | 1617 |
| 16 | 1928 | 1777 | 1729 | 1966 | 1837 | 1799 | 1823 | 1832 | 1787 | 1851 | 1852 | 1998 | 2330 | 2282 | 2457 | 2375 | 1909 | 1914 |
| 17 | 2212 | 1989 | 2005 | 2220 | 2083 | 2257 | 2100 | 2023 | 2010 | 2132 | 2078 | 2407 | 2393 | 2578 | 2808 | 2903 | 2026 | 2301 |
| 18 | 2478 | 2326 | 2333 | 2459 | 2197 | 2421 | 2466 | 2358 | 2441 | 2429 | 2440 | 3056 | 2496 | 2948 | 3377 | 2786 | 1788 | 2459 |
| 19 | 2669 | 2508 | 2553 | 2643 | 2283 | 2534 | 2707 | 2474 | 2716 | 2662 | 2822 | 2954 | 2675 | 3426 | 3502 | 2741 | 3241 | 2562 |
| 20 | 3052 | 2777 | 2889 | 2887 | 2643 | 2870 | 2942 | 2887 | 3207 | 3000 | 3140 | 2899 | 2719 | 3199 | 4089 | 3269 | 2037 | 2843 |
| 21 | 3363 | 2898 | 3076 | 3029 | 3105 | 3198 | 3063 | 3036 | 3739 | 3263 | 2939 | 4177 | 3773 | 3411 | 5186 | 3031 | 3837 | 3465 |
| 22 | 3993 | 3422 | 3637 | 3487 | 3192 | 3471 | 3663 | 3584 | 3851 | 3754 | 3807 | 3682 | 4384 | 4287 | | 4255 | 3757 | 3477 |
| 23 | 4092 | 3299 | 3525 | 3556 | 2514 | 3485 | 3592 | 3699 | 4289 | 3787 | 3240 | 4206 | 4534 | 3476 | | 3830 | | 3126 |
| 24 | 4998 | 4172 | 4453 | 4067 | | 4541 | 4108 | 4442 | 4670 | 4493 | 4206 | 4220 | 4820 | | | | | 2873 |

**Mean Length
(cm)**

| Age | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 |
|-----------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|------|
| 1 | 4.7 | | 5.5 | | | | 5.1 | 3.6 | 4.7 | 4.1 | 4.0 | 4.8 | 2.2 | 3.5 | | | | |
| 2 | 7.4 | 8.1 | 8.0 | 9.2 | 9.9 | 8.8 | 8.6 | 8.9 | 8.9 | 8.9 | 7.3 | 7.7 | 5.3 | 7.0 | 5.4 | 6.5 | | 7.4 |
| 3 | 9.8 | 9.5 | 9.8 | 10.2 | 10.4 | 9.8 | 10.1 | 9.9 | 9.9 | 9.9 | 9.7 | 9.7 | 8.9 | 9.0 | 8.4 | 8.0 | 8.4 | 8.8 |
| 4 | 11.0 | 10.7 | 10.9 | 10.9 | 11.2 | 11.1 | 11.2 | 11.3 | 11.0 | 11.1 | 11.1 | 11.2 | 11.1 | 10.4 | 10.1 | 9.7 | 10.2 | 10.1 |
| 5 | 12.7 | 12.8 | 12.5 | 12.4 | 12.6 | 12.4 | 12.6 | 12.7 | 12.5 | 12.7 | 12.5 | 12.5 | 12.7 | 12.4 | 11.6 | 11.5 | 12.3 | 11.3 |
| 6 | 14.2 | 14.0 | 14.0 | 13.8 | 13.7 | 13.7 | 14.0 | 13.7 | 13.7 | 13.9 | 14.1 | 13.6 | 13.9 | 13.7 | 13.1 | 13.5 | 13.6 | 12.5 |
| 7 | 15.4 | 15.5 | 15.4 | 15.3 | 15.0 | 15.3 | 15.4 | 15.5 | 15.1 | 15.2 | 15.4 | 15.0 | 15.3 | 15.1 | 15.0 | 14.9 | 15.2 | 14.0 |
| 8 | 16.6 | 17.0 | 16.9 | 16.8 | 16.5 | 16.6 | 16.4 | 16.8 | 16.3 | 16.4 | 16.5 | 16.7 | 17.1 | 16.6 | 16.8 | 16.9 | 17.1 | 16.4 |
| 9 | 18.1 | 18.1 | 18.2 | 18.2 | 18.1 | 17.9 | 17.6 | 18.5 | 17.8 | 17.8 | 17.7 | 17.7 | 18.2 | 17.9 | 18.5 | 18.3 | 17.9 | 18.1 |
| 10 | 19.5 | 19.1 | 19.2 | 19.2 | 19.3 | 19.2 | 18.9 | 19.6 | 18.7 | 18.9 | 18.9 | 19.3 | 19.8 | 19.5 | 19.1 | 20.0 | 18.8 | 19.2 |
| 11 | 20.9 | 20.6 | 20.5 | 20.4 | 20.7 | 20.6 | 20.3 | 20.8 | 20.3 | 20.2 | 19.8 | 21.5 | 20.5 | 20.9 | 20.8 | 22.3 | 20.2 | 20.9 |
| 12 | 22.0 | 22.0 | 21.6 | 21.2 | 21.4 | 21.6 | 21.5 | 22.2 | 21.2 | 21.2 | 21.0 | 22.5 | 22.1 | 22.5 | 22.7 | 23.0 | 21.7 | 23.2 |
| 13 | 23.3 | 23.7 | 23.2 | 22.7 | 22.5 | 23.0 | 22.9 | 23.8 | 23.1 | 22.8 | 22.1 | 23.7 | 24.0 | 23.5 | 24.5 | 25.5 | 25.3 | 24.9 |
| 14 | 24.8 | 25.3 | 25.0 | 24.9 | 24.3 | 24.6 | 24.6 | 24.8 | 25.0 | 24.9 | 25.1 | 26.1 | 25.1 | 23.9 | 27.2 | 27.1 | 24.6 | 26.7 |
| 15 | 26.4 | 26.7 | 26.6 | 26.7 | 27.2 | 26.4 | 26.3 | 27.1 | 26.5 | 26.9 | 26.0 | 28.5 | 29.2 | 27.7 | 29.5 | 28.3 | 26.9 | 27.0 |
| 16 | 27.7 | 28.0 | 27.7 | 28.1 | 28.0 | 27.8 | 27.7 | 28.1 | 27.5 | 27.9 | 27.8 | 28.9 | 29.8 | 30.2 | 30.9 | 29.7 | 28.3 | 28.8 |
| 17 | 29.2 | 29.2 | 29.2 | 29.4 | 29.5 | 30.3 | 29.4 | 29.1 | 28.8 | 29.5 | 29.1 | 30.9 | 29.7 | 31.5 | 32.3 | 32.2 | 29.3 | 30.7 |
| 18 | 30.6 | 30.8 | 30.9 | 30.8 | 30.2 | 31.2 | 31.3 | 30.8 | 30.8 | 31.0 | 30.9 | 33.8 | 30.7 | 33.1 | 35.0 | 31.2 | 27.1 | 31.5 |
| 19 | 31.5 | 31.7 | 31.8 | 31.5 | 30.6 | 31.7 | 32.3 | 31.4 | 32.0 | 32.0 | 32.7 | 33.4 | 31.3 | 35.0 | 35.0 | 31.2 | 34.6 | 31.8 |
| 20 | 33.0 | 32.8 | 33.2 | 32.8 | 32.1 | 33.2 | 33.3 | 33.1 | 34.1 | 33.5 | 34.1 | 33.1 | 31.6 | 34.1 | 37.2 | 33.2 | 29.2 | 33.1 |
| 21 | 34.1 | 33.3 | 34.0 | 33.4 | 34.1 | 34.3 | 33.8 | 33.8 | 36.1 | 34.5 | 33.2 | 37.8 | 36.5 | 34.9 | 40.2 | 32.5 | 36.8 | 35.4 |
| 22 | 36.6 | 35.3 | 36.0 | 35.3 | 34.5 | 35.4 | 36.0 | 35.8 | 36.5 | 36.3 | 36.5 | 36.2 | 38.5 | 38.1 | | 36.6 | 36.5 | 35.5 |
| 23 | 37.0 | 34.7 | 35.5 | 35.2 | 31.6 | 35.3 | 35.8 | 36.2 | 38.0 | 36.4 | 34.3 | 37.9 | 38.9 | 35.2 | | 35.5 | | 34.1 |
| 24 | 40.2 | 37.8 | 38.7 | 37.5 | | 38.9 | 37.5 | 38.7 | 39.3 | 38.8 | 37.8 | 38.0 | 39.8 | | | 33.8 | | 33.2 |

Table 5.- Available surveys biomass indices for the roughhead grenadier Subareas 2 and 3 stock, with their depth and area coverage.

| Survey | Time Series | NAFO Division | Depth Range |
|-----------------------------|------------------|---------------|--------------|
| Canadian Fall Survey | 1978 – 1994 | 2GHJ 3KLMNO | <730 m |
| | 1995 – 2009 | 2GHJ 3KLMNO | <1500 m |
| Spanish Surveys in Div. 3NO | 1997 - 2009 | 3NO | <1500 m |
| EU Flemish Cap Surveys | 1988 – 2003 | 3M | <730 m |
| | 2004– 2009 | 3M | <1500 m |
| Canadian Spring Survey | 1978 - 2006 | 3LNO | <730 m |
| Canadian deepwater | 1991, 1994, 1995 | 3LMN | <1500 m |
| Russian | 2001 - 2002 | 3M | 120 - 1280 m |
| EU Deepwater | 1996 | 3LMN | 700 - 3100m |

Table 6.- Available roughhead grenadier surveys biomass indices series. Mean Weight Per Tow for all except the Canadian Spring survey and Canadian deepwater survey are measure as total biomass.

| | Can Autumn 2J+3K | Can spring 3LNO(up to 750 m.) | Canadian deepwater survey | Spanish 3NO | EU Flemish Cap (up to 750 m.) | EU Flemish Cap (up to 1400 m.) |
|-------------|---------------------|-------------------------------------|---------------------------------|----------------|----------------------------------|-----------------------------------|
| 1991 | | | 16215 | | 1.66 | |
| 1992 | | | | | 1.96 | |
| 1993 | | | | | 3.76 | |
| 1994 | | | 26588 | | 2.46 | |
| 1995 | 0.65 | | 46668 | | 1.94 | |
| 1996 | 1.29 | 2883 | | | 1.69 | |
| 1997 | 1.48 | 3103 | | 3.81 | 1.49 | |
| 1998 | 1.71 | 5078 | | 7.05 | 2.10 | |
| 1999 | 1.50 | 4043 | | 4.53 | 1.56 | |
| 2000 | 1.66 | 5095 | | 7.08 | 1.31 | |
| 2001 | 2.45 | 4948 | | 5.73 | 2.58 | |
| 2002 | 1.91 | 3116 | | 5.46 | 1.50 | |
| 2003 | 1.73 | 4297 | | 7.40 | 2.92 | |
| 2004 | 2.57 | 4361 | | 12.09 | 4.47 | 14.52 |
| 2005 | 2.42 | 15608 | | 11.10 | 2.97 | 10.26 |
| 2006 | 2.60 | | | 11.11 | 4.89 | 9.26 |
| 2007 | 3.02 | | | 6.93 | 1.7 | 5.94 |
| 2008 | * | | | 7.93 | 3.68 | 9.91 |
| 2009 | 3.41 | | | 9.15 | 0.96 | 5.97 |

* Not available

Table 7 .- Flemish Cap Survey till 700 m depth and Spanish 3NO survey Mean numbers Per Tow (MNPT) by age.

[illegible]

Table 8 .- Aspic input files used in the different runs. In red parameters changed from run 1 (Ind1). Goodness of fit and calculates values for the parameters. In red parameters values close to the limits. Yellow shadows are fixed values for parameters.

| | Ind1 | | | Ind4 | | | Ind5 | | | Ind52 | | |
|-----------------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|----------|
| MC Search | 0 | 20000 | | 1 | 50000 | | 1 | 50000 | | 1 | 50000 | |
| Conver criteria | 1.00E-08 | | | 1.00E-08 | | | 1.00E-08 | | | 1.00E-08 | | |
| Restars | 3.00E-08 | 6 | | 3.00E-08 | 15 | | 3.00E-08 | 15 | | 3.00E-08 | 15 | |
| Gen Mode | 1.00E-04 | 12 | | 1.00E-04 | 12 | | 1.00E-04 | 12 | | 1.00E-04 | 12 | |
| Max F | 8 | | | 8 | | | 8 | | | 8 | | |
| Penalty B1>K | 0 | | | 0 | | | 0 | | | 0 | | |
| N° Series | 3 | | | 3 | | | 3 | | | 3 | | |
| Weight series | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| B1/K | 0.5 | | | 0.5 | | | 0.5 | | | 0.5 | | |
| MSY | 1.00E+04 | | | 1.00E+04 | | | 1.00E+04 | | | 1.00E+04 | | |
| K | 2.00E+05 | | | 2.00E+05 | | | 2.00E+05 | | | 2.00E+05 | | |
| qi | 6.00E-05 | 2.00E-04 | 9.00E-05 | 6.00E-05 | 2.00E-04 | 9.00E-05 | 6.00E-05 | 2.00E-04 | 9.00E-05 | 6.00E-05 | 2.00E-04 | 9.00E-06 |
| Parameters | 6 | | | 6 | | | 6 | | | 6 | | |
| MSY lim | 1.00E+03 | 1.00E+05 | | 1.00E+03 | 1.00E+05 | | 1.00E+03 | 1.00E+06 | | 1.00E+03 | 1.00E+06 | |
| K lim | 5.00E+04 | 5.00E+06 | | 5.00E+04 | 5.00E+06 | | 5.00E+04 | 5.00E+07 | | 5.00E+04 | 5.00E+07 | |
| Seed | 1803285 | | | 1900285 | | | 1900285 | | | 1900285 | | |
| R2 q1 | | | -0.033 | | | -0.032 | | | -0.03 | | | -0.029 |
| R2 q2 | | | 0.316 | | | 0.315 | | | 0.318 | | | 0.318 |
| R2 q3 | | | 0.608 | | | 0.606 | | | 0.605 | | | 0.602 |
| contrast index | | | 0.1158 | | | 0.1127 | | | 0.0408 | | | 0.0355 |
| nearness index | | | 0.7257 | | | 0.7205 | | | 0.5798 | | | 0.5696 |
| B1/K | | 0.110 | | | 0.108 | | | 0.039 | | | 0.034 | |
| MSY | | 67200 | | | 66810 | | | 392700 | | | 543500 | |
| K | | 5000000 | | | 5000000 | | | 35390000 | | | 50000000 | |
| q(1) | | 2.83E-06 | | | 2.90E-06 | | | 1.13E-06 | | | 9.13E-07 | |
| q(2) | | 8.37E-06 | | | 8.57E-06 | | | 3.33E-06 | | | 2.70E-06 | |
| q(3) | | 2.26E-06 | | | 2.31E-06 | | | 9.00E-07 | | | 7.29E-07 | |

| | Ind6 | | | Ind7 | | | Ind8 | | | Ind13 | | |
|-----------------|----------------|----------|----------|----------------|----------|----------|----------------|----------|----------|----------------|----------|----------|
| MC Search | 1 | 50000 | | 1 | 50000 | | 1 | 50000 | | 0 | 20000 | |
| Conver criteria | 1.00E-08 | | | 1.00E-08 | | | 1.00E-08 | | | 1.00E-08 | | |
| Restars | 3.00E-08 | 15 | | 3.00E-08 | 15 | | 3.00E-08 | 15 | | 3.00E-08 | 15 | |
| Gen Mode | 1.00E-04 | 12 | | 1.00E-04 | 12 | | 1.00E-04 | 12 | | 1.00E-04 | 12 | |
| Max F | 8 | | | 8 | | | 8 | | | 8 | | |
| Penalty B1>K | 0 | | | 0 | | | 0 | | | 0 | | |
| N° Series | 3 | | | 3 | | | 3 | | | 3 | | |
| Weight series | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 | 1.00E+00 |
| B1/K | 0.5 | | | 0.5 | | | 0.5 | | | 0.5 | | |
| MSY | 1.00E+04 | | | 1.00E+04 | | | 1.00E+04 | | | 1.00E+04 | | |
| K | 2.00E+05 | | | 2.00E+05 | | | 2.00E+05 | | | 5.00E+04 | | |
| qi | 6.00E-05 | 2.00E-04 | 9.00E-05 | 6.00E-05 | 2.00E-04 | 9.00E-05 | 6.00E-05 | 2.00E-04 | 9.00E-05 | 6.00E-05 | 2.00E-04 | 9.00E-05 |
| Parameters | 5 (B1/K = 0.7) | | | 5 (B1/K = 0.7) | | | 5 (B1/K = 0.7) | | | 5 (B1/K = 0.5) | | |
| MSY lim | 1.00E+03 | 1.00E+06 | | 1.00E+03 | 1.00E+06 | | 1.00E+03 | 1.00E+06 | | 1.00E+03 | 1.00E+05 | |
| K lim | 5.00E+04 | 5.00E+07 | | 5.00E+03 | 5.00E+07 | | 5.00E+03 | 5.00E+07 | | 5.00E+03 | 5.00E+06 | |
| Seed | 1900285 | | | 1900285 | | | 1803285 | | | 1803285 | | |
| R2 q1 | | | -0.007 | | | -0.006 | | | 0.037 | | | -0.002 |
| R2 q2 | | | 0.175 | | | 0.13 | | | 0.255 | | | 0.247 |
| R2 q3 | | | 0.315 | | | 0.206 | | | 0.363 | | | 0.404 |
| contrast index | | | 0.273 | | | 0.2352 | | | 0.4128 | | | 0.3452 |
| nearness index | | | 0.8278 | | | 0.8 | | | 0.942 | | | 1 |
| B1/K | | 0.700 | | | 0.700 | | | 0.700 | | | 0.500 | |
| MSY | | 6327 | | | 68170 | | | 6091 | | | 73040 | |
| K | | 50000 | | | 2430000 | | | 16700 | | | 2919000 | |
| q(1) | | 5.81E-05 | | | 1.09E-06 | | | 1.74E-04 | | | 1.12E-06 | |
| q(2) | | 1.85E-04 | | | 3.41E-06 | | | 5.51E-04 | | | 3.37E-06 | |
| q(3) | | 4.86E-05 | | | 9.00E-07 | | | 1.45E-04 | | | 9.00E-07 | |

Table 9 .- XSA result for Recruitment (Age 3), Total biomass and mean F ages 6 to 13(Fbar) as well as Total catches by year.

| | Recruit (age 3) | Total Bio | CATCHES | FBAR 6-13 |
|------|-----------------|-----------|---------|-----------|
| 1992 | 15211 | 32186 | 6725 | 0.2692 |
| 1993 | 21817 | 27985 | 4395 | 0.2153 |
| 1994 | 22439 | 28658 | 4023 | 0.2109 |
| 1995 | 19758 | 36726 | 3982 | 0.1609 |
| 1996 | 19764 | 36863 | 4135 | 0.1767 |
| 1997 | 23405 | 39947 | 4740 | 0.1704 |
| 1998 | 26740 | 42419 | 7270 | 0.2938 |
| 1999 | 20797 | 49670 | 7160 | 0.2466 |
| 2000 | 18347 | 42670 | 4767 | 0.2073 |
| 2001 | 14148 | 41678 | 3117 | 0.1251 |
| 2002 | 14457 | 47828 | 3657 | 0.1164 |
| 2003 | 14263 | 44751 | 3984 | 0.1097 |
| 2004 | 15869 | 50057 | 3182 | 0.0779 |
| 2005 | 11394 | 51790 | 1456 | 0.0366 |
| 2006 | 11236 | 69820 | 1420 | 0.032 |
| 2007 | 7667 | 73777 | 664 | 0.0108 |
| 2008 | 12402 | 54070 | 847 | 0.0247 |
| 2009 | 15993 | 75373 | 629 | 0.0206 |

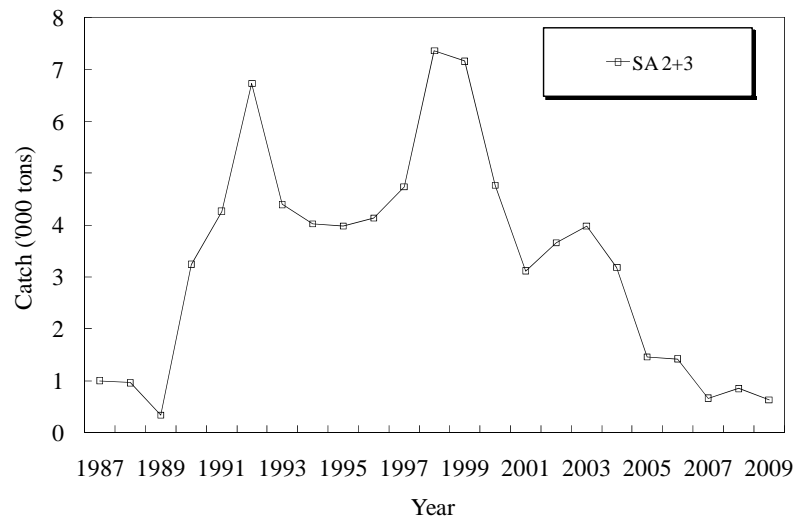


Fig. 1-. STACFIS roughhead grenadier NAFO Subarea 2 and 3 nominal catches (t).

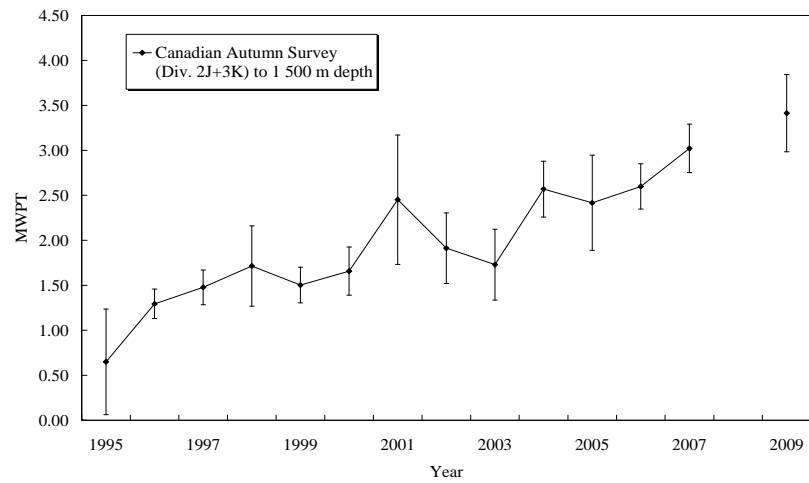


Fig. 2- Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the Canadian autumn (Div. 2J3K) survey

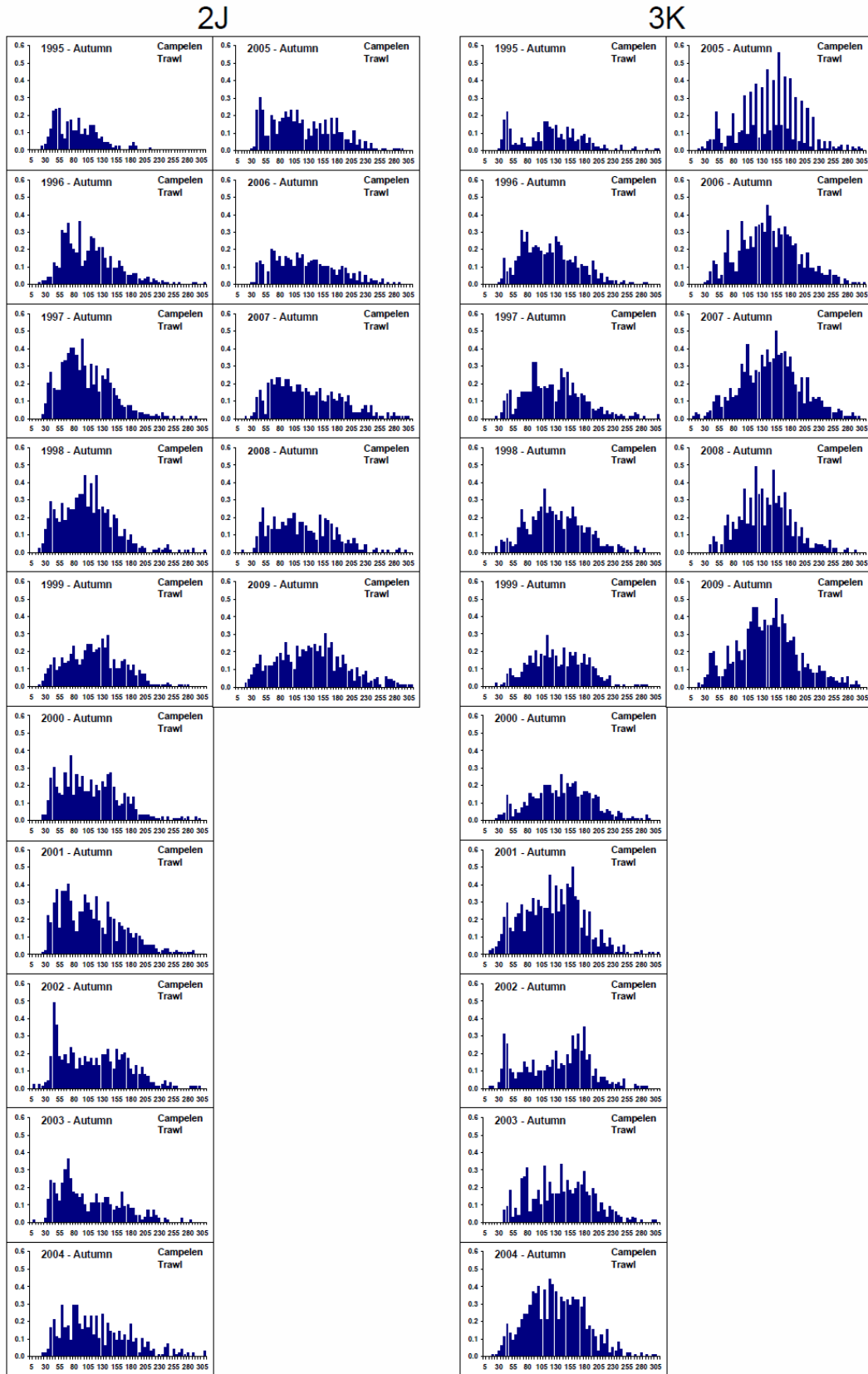


Fig. 3 -. Roughhead Grenadier length frequency distribution from Canadian Autumn surveys to Div. 2J3K. Mean Number Per Tow (MNPT). X-axis is AFL measure in mm.. (D. Power, DFO St. John's pers. comm.).

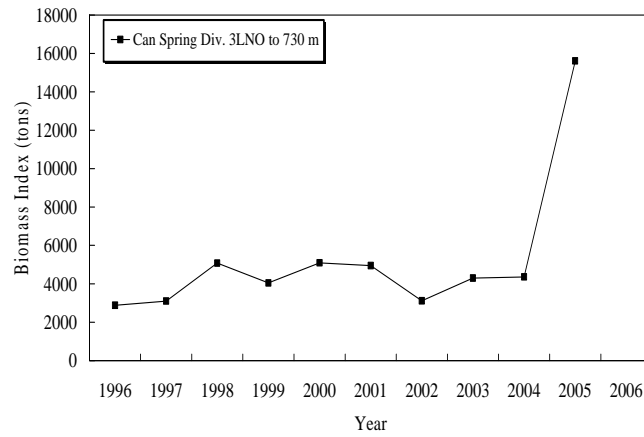


Fig 4.- Roughhead grenadier in Subareas 2+3: biomass indices from the Canadian spring surveys.

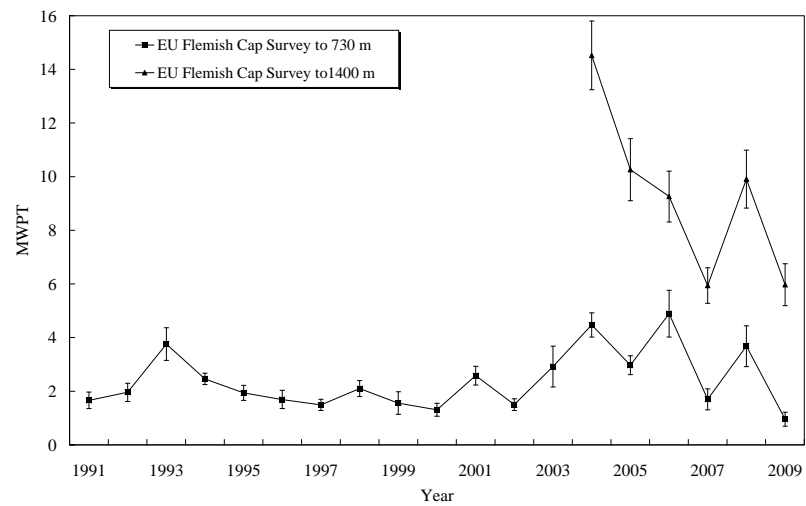


Fig. 5.-. Roughhead grenadier in Subareas 2+3: biomass indices (+/- SE) from the EU Flemish Cap survey.

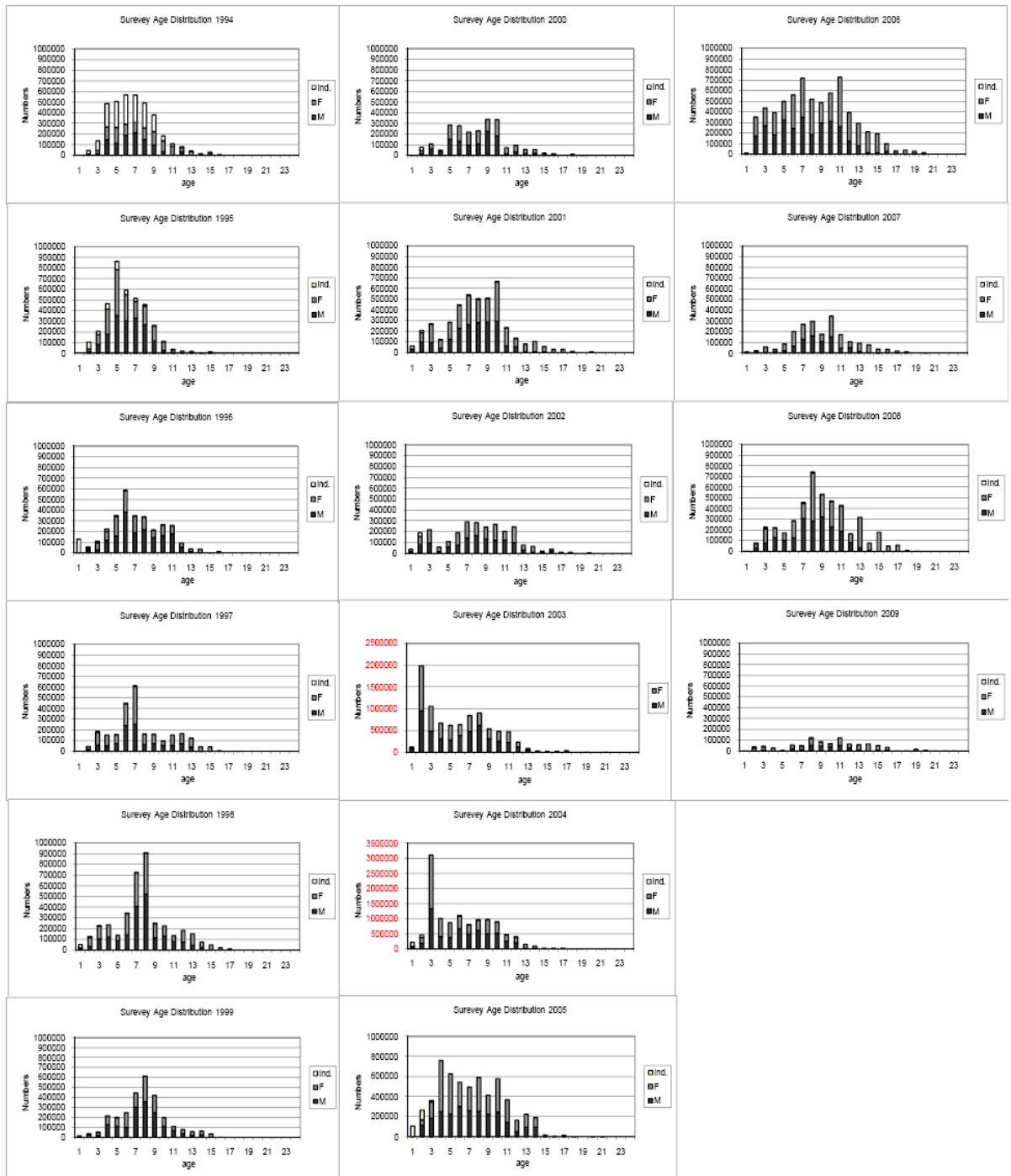


Fig. 6. – EU Flemish Cap survey age distribution, by sex till 700 m. In red different scale.

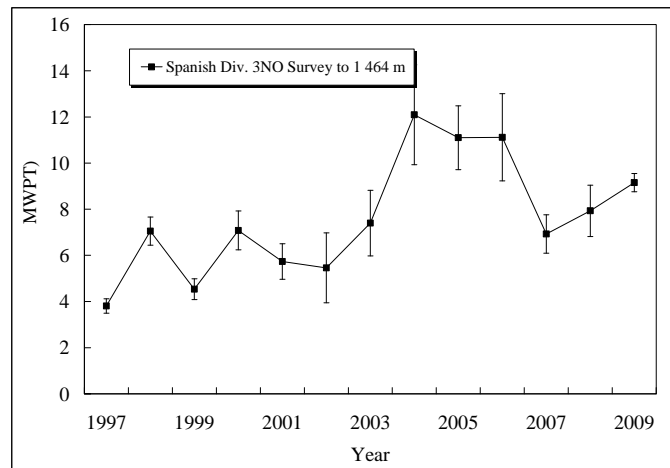


Fig. 7.- Roughhead grenadier in Subareas 2+3: biomass indices (\pm SE) from the Spanish Div. 3NO survey.

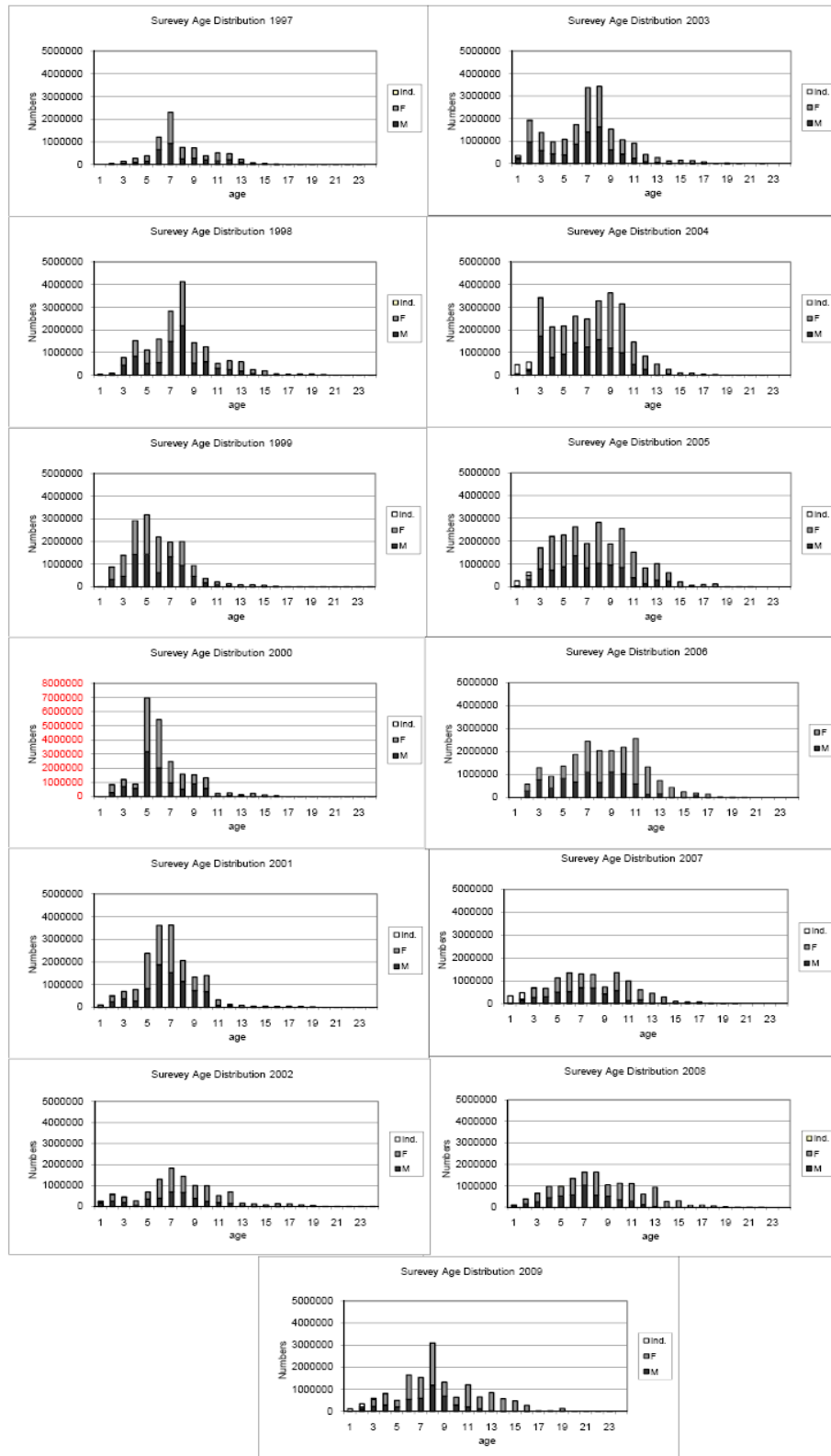


Fig. 8 . – Spanish 3NO survey age distribution, by sex . In red different scale.

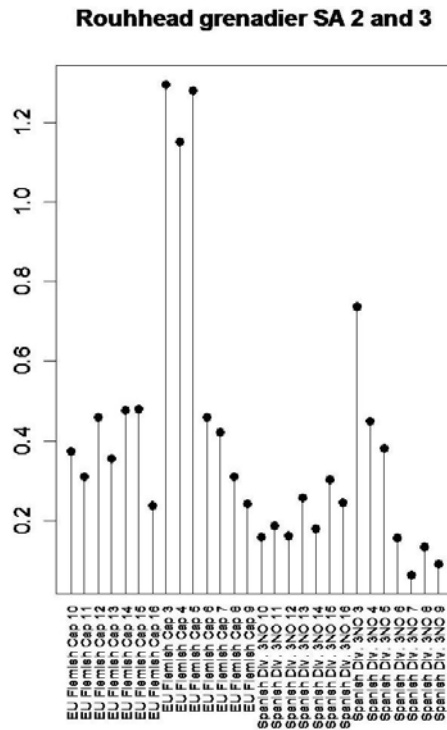


Fig. 9 – Standard Error (SE) of the log catchability residuals for EU Flemish Cap and Spanish 3NO surveys by year and age.

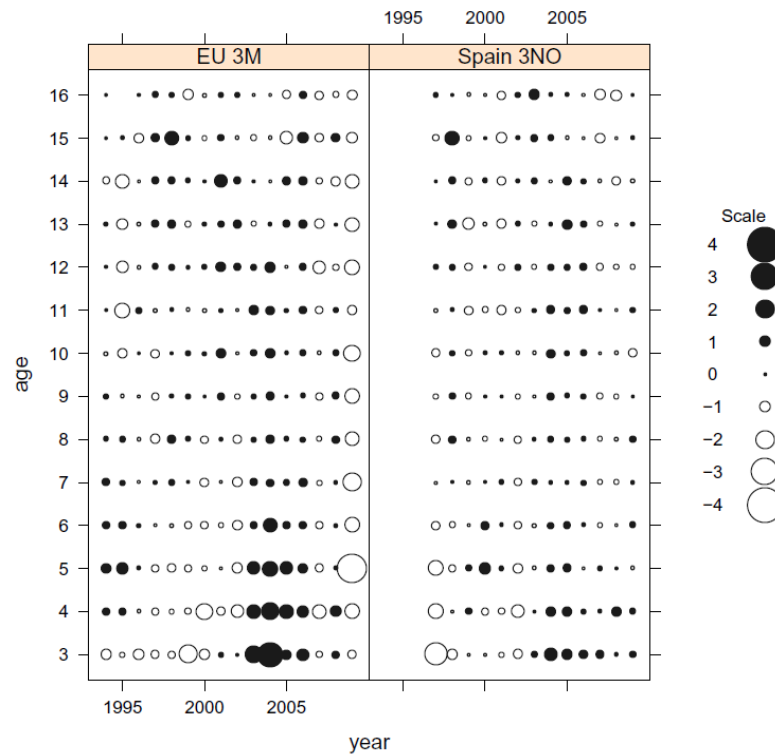


Fig. 10 – The log catchability residuals for Flemish Cap and Spanish 3NO surveys by year and age.

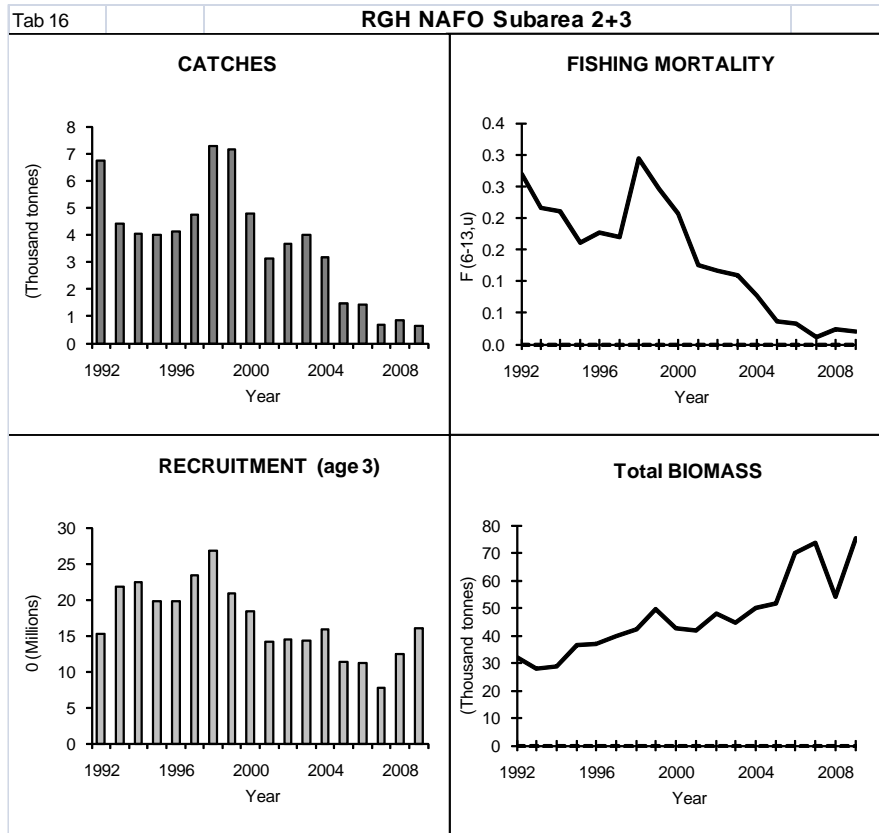


Fig. 11 – Total catches and XSA result for Total biomass, mean F ages 6 to 13 (F_{bar}) and recruitment (Age 3).

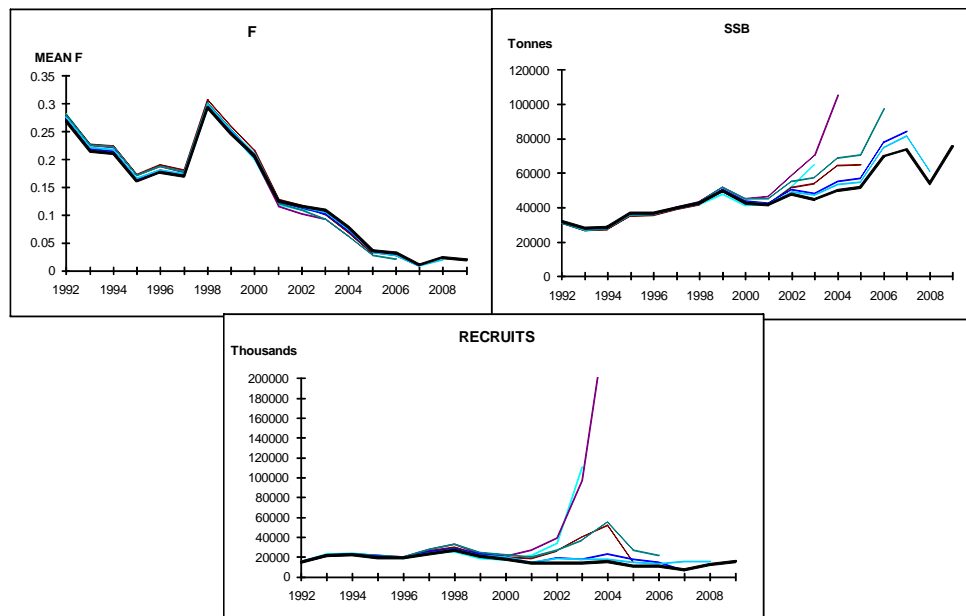


Fig. 12 – XSA retrospective results for Total biomass, mean F ages 6 to 13 (F_{bar}) and recruitment (Age 3).

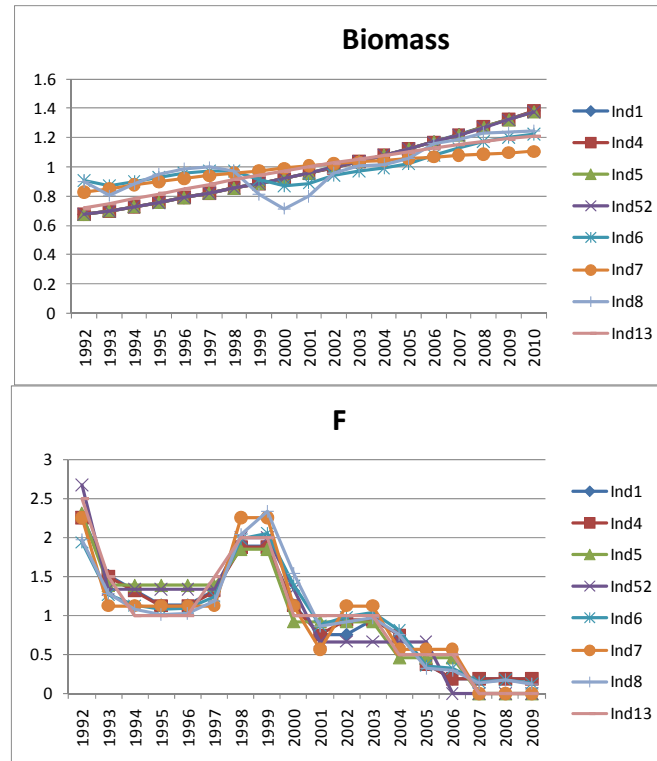


Fig. 13 – ASPIC results for total biomass and Fishing mortality obtained in the different runs. Total biomass and Fishing mortality were normalized to their mean for each run.

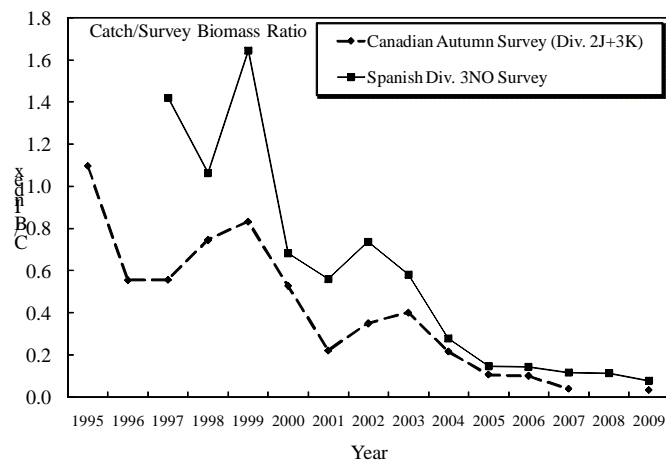


Fig. 14 – The catch / biomass (C/B) indexes obtained using the Canadian fall survey (2J+3K) and the Spanish 3NO biomass index in the period 1995-2009.

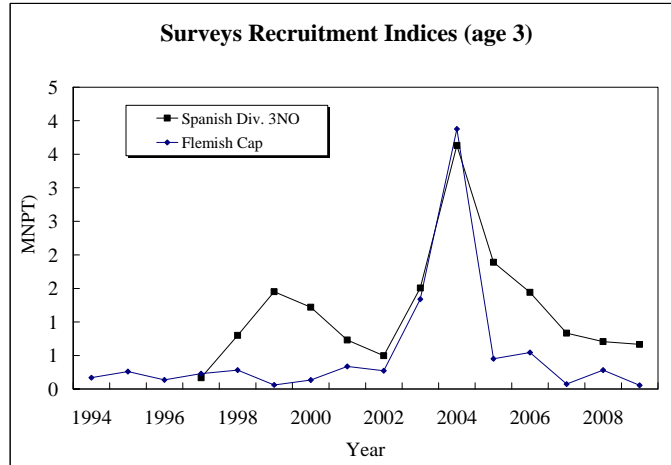


Fig. 15 – Roughhead grenadier in Subareas 2+3: Spanish Div. 3NO survey and EU Flemish Cap survey abundance (MNPT) at ages 3.

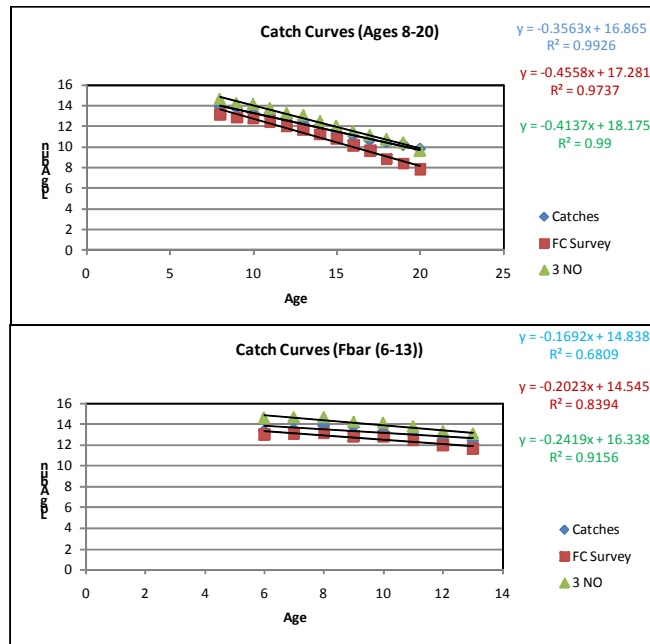


Fig. 16 – The catch curves for commercial catches (1992-2009), Flemish Cap survey (1994-2009) and Spanish 3NO survey (1997-2009) for ages 8 to 20 and 6 to 13.